This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

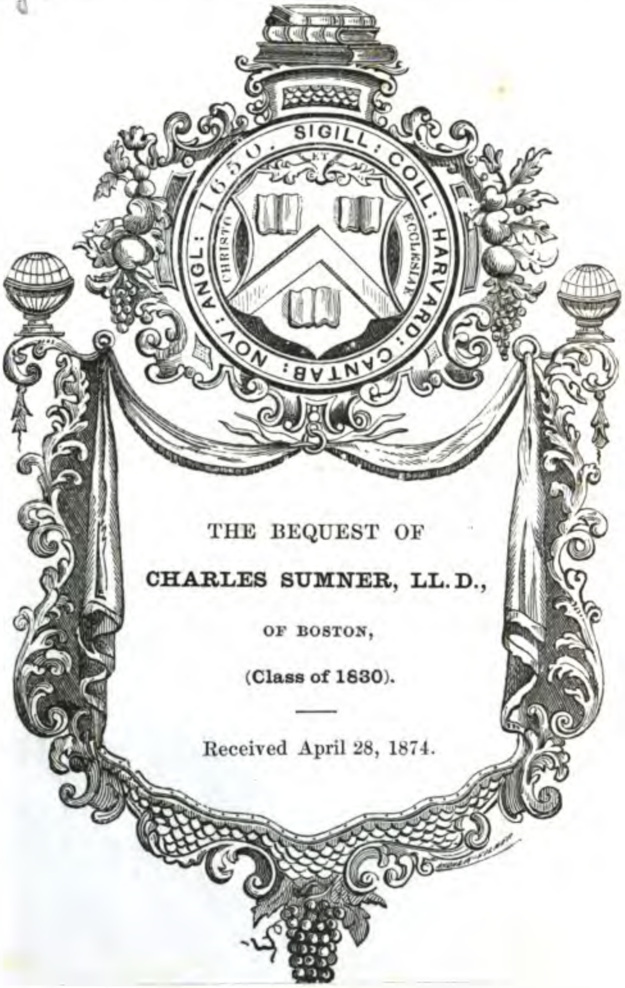
Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Phys
428
58.5

34.169

Bd. 1875

Phys 428.58.5


SIGILL: COLL: HARVARD: CANTAB: NOV: ANGL: 1650.
CHRISTO ET ECCLESIAE

THE BEQUEST OF
CHARLES SUMNER, LL. D.,
OF BOSTON,
(Class of 1830).

Received April 28, 1874.

SCIENCE CENTER LIBRARY

Hennessy, Henry.
1858.

ON

A UNIFORM SYSTEM

OF

WEIGHTS, MEASURES, AND COINS

FOR

ALL NATIONS.

BY HENRY HENNESSY, F.R.S., M.R.I.A.,
PROFESSOR OF NATURAL PHILOSOPHY IN THE CATHOLIC UNIVERSITY OF IRELAND.

PUBLISHED BY THE
International Association for obtaining a Uniform Decimal System
of Measures, Weights, and Coins.

5 LONDON:
SOLD BY BELL AND DALDY, 186 FLEET STREET,
AND AT THE
OFFICE OF THE ASSOCIATION, 11 BUCKINGHAM STREET, ADELPHI.
1858.

Price Six Pence.

Phys 428.56.5

1874, April 28.
Bequest of
Hon. Charles Sumner,
of Boston.
(H. U. 1830.)

THE FOLLOWING TRACTS,

PUBLISHED BY THE ASSOCIATION, ARE SOLD AT THE OFFICE,
11 BUCKINGHAM STREET, ADELPHI,
AND
BY BELL AND DALDY, 186 FLEET STREET.

---

1. Narrative of the Origin and Formation of the International Association. By James Yates, Vice-President. Second Edition. 1s.
2. Decimal Coinage. Should it be International? By T. C. Mossom Meekins, Honorary Secretary. 6d.
3. Prospectus of the Association. 1d.
4. Concise Narrative of the Origin of the Association. 1d.
5. Rules and Regulations. 1d.
6. First Report of the Council, with Appendix, Proceedings, etc. 6d.
7. Second Report of the Council, with List of Contributions, etc. 3d.
8. Tables of Local Weights and Measures used in the United Kingdom. 6d.
9. The Decimal System of Measures, Weights, and Money. By William Arthur Jones, M.A., Corresponding Member. Third Edition. 6d.
10. What is the Best Unit of Length? An inquiry, addressed to the International Association, with answers from the British Branch of the Association, showing that the Best Unit of Length is the Metre. 2s.

J. F. FOWLER, PRINTER, 3 CROW STREET, DAME STREET, DUBLIN.

ON A UNIFORM SYSTEM,

ETC., ETC.,

Simplicity important in business calculations.

CALCULATIONS connected with money, weights, and measures make up a great part of the active business of life; and by far the most extensive application of the science of numbers is that made in our daily transactions of buying and selling. Few who are engaged in such calculations will be prepared to state that, considered as arithmetical exercises, they are accompanied with any peculiar intellectual pleasure. The astronomer, who labours over an apparently inextricable mass of numbers, usually feels some interest in a task which even in its progress unfolds relations of symmetry in the arrangements of the material universe; yet he would gladly welcome new processes of computation, which, without impairing the accuracy of his results, would diminish the labour necessary for their evolution. It is, therefore, extremely natural that persons engaged in the ordinary calculations of every-day business should, in like manner, be willing to adopt methods for lessening the time and labour devoted to their computations. In order to arrive at sound conclusions on this question, it is first indispensable to consider the means employed in all kinds of calculations.

Mode of counting universally adopted by mankind

Mankind have been so long and so universally accustomed to count by tens, that the decimal system of numeration has become associated in our minds with the groundwork of all numerical computations. But this might have been otherwise, and if man had been created with four or six fingers on each hand, instead of five, we should most probably now employ either eight or twelve as the *modulus* of our numerical system. Much might be said as to the advantages attending the employment of either of these numbers as a numerical modulus, but such remarks would be wholly speculative at the present day, and would probably never possess the slightest practical utility.

should be employed with reference

The calculations of trade have reference either to objects capable of being directly and separately counted, such as pieces of money, or of being counted by comparison with other objects, such as most of the solids and all the liquids to all countable things.

that are commercial commodities. Such substances must generally be weighed or measured before they can become subjects for computation. In order to effect these processes in such a way as to attach definite notions to our results, we refer all weights and measures to certain fixed standards. Had we only one coin, one weight, and one measure, as we have only one UNIT in arithmetic, much practical inconvenience would result; and accordingly civilized nations have been long accustomed to employ a great variety of coins, weights, and measures. Every single member of each of these classes has usually some fixed numerical relation with the other individuals of its class; but, as the fundamental standards employed by different nations have been generally different, so have been the relations among their groups of coins, weights, and measures. Yet as these relations necessarily form what constitutes the subject matter of ordinary computations, it follows that they should harmonize as closely as possible with the numerical system employed in such computations. If, therefore, we count numbers, considered as abstract representations of countable things, by tens, we should also count the real things themselves in the same way, whether they happen to be coins, weights, or measures. In other words, having adopted a decimal system of arithmetic as a pure science, a decimal system of counting objects to which it is applied will be the easiest and most natural. Had we a duodecimal or any other system of arithmetic, a corresponding system of counting coins, weights, and measures would be the simplest; but with our actual system of computation, calculations referring to objects whose relations are discordant with that system, must be attended with increased trouble and complication. These general arguments are true not merely to-day, but were equally true thousands of years ago, when man first commenced numbering; they are true not merely for us, but for every nation on the surface of the Earth. The rigorous truth of these conclusions has, moreover, been verified thousands of times in practice, and is now apparently universally admitted; yet different nations have for centuries employed systems of coins, weights, and measures, not only unconnected one with the other, but framed without any immediate reference to the system of numbering which has been almost instinctively adopted by every family of the human race.

Although an important advance has been made in recent times towards the establishment of an improved system, the great nation which has had the honour of taking the first step in this rational course, has as yet been followed by but few others,[1] and by none belonging to the limited number which can bear comparison with her, in population, territorial extent, and material resources. Improvements which require the most simple change in a man's mental habits, even when these improvements spare trouble to the lazy mind itself, are often slowly received by an individual: such improvements are surrounded with difficulties incomparably more serious when a great number of minds must agree before they can be adopted.

Resistance to analogous improvements illustrated, by the

Our simple and elegant arithmetical notation, usually called the Arabic system of numerals, made very gradual progress into Europe, through Arabia, from India, where it was originally invented. Its advantages over the Greek and Roman systems of notation are so immense, that its absence was undoubtedly the principal cause of the remarkably imperfect condition of the calculating portions of astronomy and mathematics among the ancients, compared to pure geometry and its applications. To the influence of Pope Sylvester the Second is mainly due the adoption of the Arabic numerals during the middle ages in the South of Europe. But centuries elapsed before they entirely displaced the complex and cumbrous Roman numerical symbols among the northern nations. The Arabic numerals were unknown in Russia until the time of Peter the Great; they were employed in England about two centuries before, but there, the barbarous Roman system still lingered among the accounts of the exchequer down to a very recent time. And this improvement was even for a while successfully resisted by one of those statesmen[2] whose rank is usually supposed to supply all the qualities required for managing public affairs.

Arabic numerals,

The progress of the higher departments of the exact sciences was greatly retarded in England during the last century by the adherence of mathematicians to a system of notation much inferior to that employed on the continent. This

by modern mathematics,

---

[1] The system is now either in actual operation, or its introduction has been sanctioned by legislative enactments in the following states besides France, namely, Belgium, Greece, Spain, Sardinia, Holland, Lombardy, Switzerland, Modena, Mexico, Chili, Columbia, and Costa Rica. The well known union of the German States (Zollverein) for weights and measures has in part adopted the French metrical system.

[2] Lord Grenville.

arose in a great measure from natural though misdirected feelings of veneration for the memory of Newton; just as if the Genoese were to retain precisely the same methods in navigation and seamanship, as those which had been employed by Columbus. More than a century elapsed, before Newton's countrymen were able to understand that the splendid heritage which he had bestowed on mankind, was best cultivated by more manageable weapons than had been employed by the illustrious discoverer himself. In like manner, although incontestably better than that previously employed, our present mode of computing time, according to the Gregorian calendar, came very gradually into operation, except in Catholic countries, and at this day it is not yet universally adopted. In England, when the proposed reform of the calendar was first brought under the notice of the Duke of Newcastle by Lord Chesterfield, it appears that the minister was much alarmed at the project. He entreated the earl not to stir matters that had remained so long quiescent, and expressed his personal disinclination to *new-fangled things*.[3] With such powerful arguments in favour of retaining the old system, it seems wonderful that it has not held its ground up to the present day.

and by the Gregorian Calendar.

Cosmopolitan nature of a decimal system of coins, weights, and measures.

As a decimal system of coins, weights, and measures appears to have no peculiarity of a merely provincial or national character, which would adapt it solely for employment within the confines of any separate nation, it is reasonable to suppose that its general adoption by all nations would be universally attended with similarly beneficial results. Not only would the internal transactions of each country be simplified, but its external commercial intercourse would also be greatly facilitated by the similarity of its metrical and monetary arrangements with those of surrounding countries. This result would be yet more decisive were common standards adopted among the several countries. Here the peculiarities and habits of different races doubtlessly present some reasons for existing differences, and will probably interpose some obstacles to the final adoption of an universal system. Although the fundamental ideas of measure, weight, and value are now nearly alike among civilized nations, they are not so completely identical as the elementary notions of number. The primitive units of lineal measure appear generally to be derived from the dimensions of parts of the human body. Thus the foot has its equivalent designated by a corresponding word among all European languages, but its value is not the same in any two countries. Our first notions of weight are derived from the muscular effort required to sustain a mass of matter, and the commonest instrument for roughly estimating the relative weights of bodies is the hand. Arbitrary ideas of weight thus arise among men, according to their varieties of strength and physical constitution. The designations of certain units of weight also indicate their arbitrary character: thus the "stone" accounts by its very name for the actual varieties in the weight it represents. The fundamental notions of value among mankind, although still somewhat arbitrary, have been long approximating to a condition of uniformity, owing to the wide-spread circulation and universal adoption of the precious metals as representatives of wealth. A certain definite quantity of one of these metals, or of an alloy in fixed proportions, would thus assuredly be a sufficiently intelligible standard of value among all civilized nations.

---

[3] See Maty's Memoirs of Lord Chesterfield, section vi.

Twofold operation for producing uniformity of weights and measures:

The formation of a uniform system of weights, measures, and coins for all mankind would thus require a twofold operation—the adoption of the same standards, and, in the subdivisions and multiples of these for smaller or greater values, the employment of that decimal system of numeration which in their arithmetical system mankind have *already* universally adopted. Nor is it solely to the metrical arrangements of separate and independent nations that this double operation would apply. In some countries we find a multitude of provincial weights and measures, as different from each other as those belonging to entirely different races. The weights and measures of Great Britain and Ireland are thus far from being uniform in any sense. They are not only arranged without reference to the decimal enumeration, but are variable in value and in name, in different counties and provinces. Selecting a few from numerous examples of metrical curiosities, it appears that while the length of a rood at Preston is from 16½ to 24 feet, in the Vale of Leven it is 36 yards or 108 feet. The Irish acre contains 7,840 square yards, the Scotch acre 6,084. In some parts of England an acre means 4,840 square yards, while in others it means 10,240. The square rood sometimes amounts to 1,210 square yards, and sometimes

necessity for its application in Great Britain and Ireland.

only to 30¼. A bushel of wheat at one place contains 60lbs., at another place 488lbs: at Dundalk a bushel is equivalent to 20 stones; at Saltash, to 8 gallons. At Scarborough a weight of corn means 40 stones; at Whitehaven, 14 stones. The weight of a pound of butter is not always estimated in the same way even in the same locality; thus, at Stoke-upon-Trent a pound of this article might vary from 16 to 24 ounces. The hundred weight is, of course, *never* 100 lbs., but usually 112 lbs., and frequently 120 lbs. A complete list of all the names attached to the provincial weights and measures of Great Britain and Ireland would occupy more than a page, and would unquestionably present some points of interest to the philologist and antiquary. The confusion and trouble arising from these diversities in estimating the weights and quantities of articles of produce, has long excited attention and loudly demanded a remedy. In Ireland, as well as in England, complaints have been frequently uttered, commissions of inquiry instituted, blue books printed, and yet the only possible complete solution of the difficulty is constantly avoided.[4] The apathy or open opposition presented by successive British administrations during the last half century to the formal introduction of a uniform decimal system of weights, measures, and coins into the commercial system of England, will probably hereafter be pointed out in history as a remarkable instance of the superior influence of prejudices and mental indolence over the strongest claims of general utility and common sense.

The French weights and measures formerly in a very confused state;

The country to which the human race owes the first step towards the establishment of a metrical system in perfect harmony with our universal numerical system, is France. From what has been said regarding the provincial systems of Great Britain and Ireland, it will not appear surprising that France should at one time present a similar mass of confused and embarrassing weights and measures. The gradual growth of that country by the successive aggregation of its provinces, by treaty or conquest, from the most fertile and populous districts of central Europe, was highly favourable to the preservation of local peculiarities. Each newly-added province usually retained many of its laws, customs, and fiscal arrangements. It was often considered a privilege to retain what was bad, as well as what was good, and thus each provincial system of weights and measures was scrupulously preserved. Thus it happened that, previously to the Revolution, commercial transactions between remote parts of the kingdom were nearly as embarrassing as with foreign countries.

---

[4] The Agricultural Society of Ulster has honourably distinguished itself by passing a resolution, about the commencement of the present year, strongly recommending a decimal system of weights and measures; and a memorial was drawn up, praying for their legal introduction in connection with fairs and markets. The contemplated government measure was justly characterized as entirely inadequate to mee the requirements of the country.

their reform totally unconnected with revolutionary excesses;

At that early period of the Revolution, when it seemed only destined to apply wholesome remedies to the frightful abuses which had so long preyed upon the lives and happiness of the people, the confusion of weights and measures attracted the attention of the Constituent Assembly. The operations proposed for remedying these evils, and the manner in which they were carried into effect, were totally unconnected either with the absurdities or atrocities of the Revolution. It is important to dwell on this fact, for while few circumstances have more seriously retarded in other countries the reception of the French metrical system, nothing has interposed such obstacles to a fair appreciation of its merits, than the prejudices arising from its supposed connection with anarchy and violence. Such prejudices will presently be shown to be entirely groundless, for it will appear that the course of operations required for the establishment of the metrical system on a sound philosophical basis had nothing to do with the period of anarchy and terror, except that of being seriously obstructed; and for some time these operations were suspended by the very men whose names are now universally employed to personify political furor in its most odious form. But had the metrical system emanated from the party to which so many deeds of ferocious atrocity are ascribed, this would scarcely suffice as an objection, when the improvement, regarded as a result of science, might prove beneficial to man. Whatever associations may be connected with an invention, if it is good in itself, common sense will not reject it. Had Archimedes discovered the fruitful principle of hydrostatics with which his name is indissolubly associated, not by inquiries undertaken to determine the composition of Hiero's golden crown, but for the satisfaction of a whim of the bloodstained Diony-

if it were, this could not affect the result.

sius, we would not the less recognize the immense value of that principle in physical science, as one of the most important aids to experimental investigation, and we should not cease to apply it in the useful arts, as furnishing the most correct and simple method we possess for detecting specific differences between an endless variety of materials. Although the French metrical system is not openly criticised on historical grounds, yet such allusions and references to events of the Revolution have been sometimes made by those who object to the extension of that system, as sufficiently indicate the source from which they arise in minds so far resembling those of revolutionary anarchists as to see history exclusively through a mist of political prejudices.

The metrical system had nothing in common with the Republican Calendar.

The new metrical system has been sometimes erroneously connected with what is called the Republican Calendar. The former had been proposed long anterior to the latter, and while the metrical system originated from philosophical views, the calendar was a mere transient aberration of political fanaticism. Its authors could scarcely have intended it to become universal; and if Alexander von Humboldt had previously published his map of isothermal lines, the calendar would probably never have been proposed, at least as a philosophical system. In Ireland we would sometimes pass through the month called Nivose without snow, while an inhabitant of the southern hemisphere might amuse himself with skating during Thermidor, and might watch the fall of the leaf during Germinal.

Proposals in France for its establishment.

The views developed by La Condamine (1748) had long rendered the question of uniformity of measures familiar in the scientific circles of France; but in 1791 the proposal of a new system of weights and measures began to be discussed not only among scientific men, but also among some of the people who suffered from the confused state of affairs in the provinces. In the spring of 1788 the matter occupied the serious consideration of the Constituent Assembly; and a report was adopted on the 8th of May, in which the king was entreated to write to his Britannic majesty, in order that he would obtain the coöperation of the English legislature with the National Assembly for the determination of a natural unit for the comparison of weights and measures, so that, with the sanction of both nations, an equal number of commissioners, chosen from the Academy of Sciences and from the Royal Society, could meet, in order to find at the parallel of latitude half way between the equator and the pole, or any suitable parallel, the length of the second's pendulum. From the length so ascertained the representatives of the two nations were then to deduce an invariable standard for a new metrical system. In August of the same year the Constituent Assembly fully ratified this report, charging the Academy of Sciences with the determination of a system founded in nature and destined to permanently supersede the varied and jarring systems existing throughout the provinces of France. It was also proposed that the new system should be so framed as to render it acceptable to the tastes and applicable to the wants of the other civilized families of mankind. The Academy resolved therefore that its divisions should be connected according to the decimal scale, and that the units of surface, capacity, and weight should all depend on the unit of length. To determine the absolute magnitude of this unit, and to fix on a suitable standard for its comparison, became a problem of fundamental importance. The commissioners appointed by the Academy to decide on this question were Lagrange, Laplace, Borda, Monge, and Condorcet. After discussing the relative merits of the invariable length which is known to be required for the exactness of a second's pendulum at any given latitude, and of a unit taken from the dimensions of our planet, they decided on preferring the latter, as not involving the heterogeneous element of time, and being also necessarily of a more cosmopolitan character. The ten-millionth part of the arc of meridian comprised between the equator and the pole was therefore selected as the unit of linear measurement. It was assumed that, as long as the Earth continues in habitable conditions for the human race, its dimensions cannot sensibly change, and that, consequently, if the national standards of length should through physical or political causes be lost or injured, their true values could always be recovered by a direct remeasurement of the Earth, or by a fresh determination of the length of the second's pendulum, the relation between which and the standard of length having been previously determined. There cannot be a doubt that this last method would furnish the shortest and easiest mode of recovering the standard, if it happened to be injured or destroyed, for the operation of determining the dimensions of the Earth is one of the most difficult and delicate in theory, as well as tedious and laborious in

Decimal divisions are adopted;

and a fraction of the meridian is selected as the standard of length.

practice, that comes within the range of the sciences of exact observation. Had the Earth been an exact sphere, it is easily perceived from the elements of geometry, that the measured distance between two places lying on the same meridian, compared with the difference of latitude of these places, would enable us to deduce all the dimensions of the globe. The measurement might, in so simple a case, be supposed to be made directly, and the difference of latitude would be found by knowing the difference between the angles formed by the visual ray from any star with the plumb-line at each of the two stations. But the actual problem is far from being so simple as this. The Earth's surface presents deviations from a spherical shape, which, however small compared to its entire magnitude, acquire considerable importance in the exact estimation of its figure and dimensions.

Measurements already executed from which a standard might be deduced.

Long before the proposal had been made in France for adopting a standard derived from one of the dimensions of the Earth, measurements had been executed in different countries. Attempts had been made even at periods of remote antiquity, of which the little we know indicates that science has lost nothing of real value in not possessing the remainder. But if these attempts had been executed with every modern refinement, they would still have been perfectly useless for the objects of the French commissioners, as the lengths of the units of measurement employed in these early determinations have never been satisfactorily ascertained, and will probably remain for ever unknown. More recently, geodesical measurements, intended to ascertain the magnitude and figure of the Earth, had been made not only in Europe, but scientific expeditions had been sent expressly for these objects to parts of the western continent. Some of these operations are closely connected with the most splendid discoveries in the relations of the material universe that have ever been unfolded to the human mind. A result derived from one of the earliest of the European measurements induced Newton to resume certain calculations which he had laid aside as leading to conclusions discordant with observed facts, but the discordance arose only because he had to use among his data an imperfectly determined value of the Earth's radius. On substituting the more correct value, he was able to establish, that the same kind of force which produces the fall of a rain-drop on the Earth's surface, regulates in space the motions of the planets. The more refined measurements which succeeded, while furnishing materials for studying the physical conditions of our planet at remote periods of its existence, have also contributed, perhaps more than any other of the results among the sciences of observation, to verify the law of universal gravitation, not merely for definite bodies one upon the other, but for every particle of matter on all other particles.

Yet it was resolved to undertake all the preliminary work afresh.

Although it was admitted that an estimate of the standard of length deduced from some previously executed measurements of the Earth, would be more than sufficiently exact for the ordinary purposes of commerce and the arts, it appeared to the French Academy better, both for the sake of science and for the philosophical character with which the new metrical system was to be invested, to make an entirely fresh re-measurement. The inequalities of the Earth's surface, which are most obvious to ordinary observation, such as hills and valleys, prevent the direct measurement of an arc of the meridian. This arc is supposed to traverse a surface to which a plumb-line suspended over any point would be always perpendicular, or along which an observer, carrying a spirit-level, would always find the bubble at the middle of the tube. This surface, although unquestionably not the mean surface of the Earth, yet deviates from it probably in so slight a degree as to render the difference of no consequence, except in those questions of terrestrial physics, in which peculiarities of the internal structure of our planet are attempted to be studied by the aid of such phenomena as are presented to us on its surface. If the positions of certain points which are known to be on the meridian, such as the two extremities of the arc, are ascertained by any process, the length of the interval between them can be calculated. In order to determine the position of such points, a twofold series of operations must be performed; first, a general survey by the aid of methods similar to those employed in the great triangulation of the Ordnance Survey recently completed in Ireland and England; and, secondly, the determination of the positions of the triangles with regard to the meridian. The astronomical determination of the latitudes of the points whose positions have been thus ascertained by terrestrial measurements completes the work. All these operations require a large staff of practised and skilful observers, highly finished instruments of different kinds, and, finally, an ample interval of time before they can be brought to a close. The management of so important an undertaking was intrusted to a commission of the French Academy, of which Delambre and Mechain were the two astronomers more especially engaged in the geodesical operations. The arc selected for measurement is that extending between Dunkirk and Barcelona, of which the northern and by far the larger portion, extending from Dunkirk to Rodez, was to be superintended by Delambre, while his colleague undertook the management of the operations connected with the remainder. This unequal division of work arose from the presumedly greater difficulty of the Spanish part of the arc, and the circumstance that the French portion had been already twice surveyed by different observers.

Obstacles from the disturbed state of the country.

It was soon found, however, that the principal difficulties were not to be met with across the Pyrenees, but close to the walls of Paris. Mechain had scarcely commenced his journey towards the south, in the summer of 1792, when he was stopped by bands of armed citizens, and kept for a short time under arrest, until regularly liberated by authority. As he advanced, the obstacles to his progress gradually diminished, and he was able to commence his labours without any interference. In autumn he had completed the entire measurement of the angles of the several stations distributed across the Pyrenees and the north-east of Spain. The following winter was to be employed in astronomical determinations at the southern extremity of the arc.

Difficulty in obtaining proper signal marks for the geodesical operations;

Delambre was less successful in France; his first difficulty arose from the want of such prominent and distinct objects as would suffice for marking his stations with precision when observed from distances so great as the intervals between these stations. When the angular distance between two objects, each distant from an observer from twenty to thirty miles, is to be ascertained with the minute accuracy required in a geodesical survey, it is indispensable that these objects should be well defined in outline and clearly visible. Such objects as towers and steeples are well adapted for this purpose; but they are not always so situated as to meet the requirements of the system of triangulation. On this account, artificial signals have to be frequently constructed, usually pyramidal structures of wood or stone. By the aid of powerful lamps, night observations are also capable of being made with very satisfactory results. Under the existing circumstances, night signals were attended with manifest danger, and Delambre and his associates appear never to have used them except on one occasion close to Paris, and then, perhaps fortunately for themselves, in a most imperfect manner. Only a few nights before this attempt, their attention had been excited by a lurid glow towards the south. This arose from burning houses in the Place du Carrousel, for that happened to be the night of the 10th of August, 1792.

danger of night signals.

The astronomers occupied with the work encounter fresh embarrassments;

Although furnished with passports and other documents emanating from the government, the astronomers found themselves stopped by serious difficulties arising from the disturbed condition of society. The construction of signals was sometimes prevented by the people; the observers were frequently placed under armed surveillance by the district authorities. Much embarrassed by these obstacles, Delambre despatched one of his assistants to Paris to obtain fresh passports, which were rendered the more necessary from changes that had taken place in the supreme power. He prudently abstained from presenting himself, as he foresaw that he would be told to postpone his labours to an epoch of greater tranquillity, and that with such a postponement, an indefinite period might elapse before the undertaking could be again resumed. In the meanwhile he caused his passports to be *viséd* at St. Denis, where he happened to have arrived, and also took the precaution of obtaining a certificate from the district authorities. But these precautions availed little, for in half an hour afterwards the astronomer with his companions were arrested at Epinay. The instruments were regarded with particular suspicion, as perhaps dangerous counter-revolutionary engines; just as, a few centuries before, the same people might have looked upon them as apparatus connected with the mysteries of the black art. Delambre is required to display the instruments on the ground, and to explain their use. As may be readily supposed, not one among such a cultivated audience can understand his explanations. He tries vainly to excite the interest of two surveyors who happen to have got into the crowd, by showing the close affinity between his operations and the labours of their profession. These men would not compromise themselves by saying anything; they dared not oppose themselves to the tone which was now so prevalent among the multitude. After a discussion of three hours, the astronomers were conducted back to St. Denis under armed escort. The open place before the venerable mausoleum of the

they are arrested,

kings of France was filled with groups of republican volunteers waiting to be armed before marching to defend the frontier. The prisoners had to pass through this motley crowd; their carriages are explored; a heap of sealed letters addressed to the authorities of the departments in which the geodesical operations were to be carried on are discovered. The letters are speedily opened and publicly read, when they turn out to be only circulars, in which the Committee of Public Instruction of the National Assembly recommend the bearers to the good offices of the official personages to whom they are addressed. When the curiosity of the crowd had been satisfied about the letters, they next turn to the instruments. These are quickly displayed upon the open part of the square, and Delambre is once more compelled to attempt a lecture on geodesy under circumstances at once terrible and ludicrous. The day was rapidly waning; the last rays of sunset had long since tinged the summit of the cathedral, and objects close to the ground were no longer distinctly visible in the growing dusk of twilight. The first ranks of the numerous audience saw little, and heard without understanding; the more remote heard less, and saw nothing. Impatient murmurs arose; cries began to be heard, suggesting the usual expeditious means employed at the time for cutting short all doubts. The president of the district has the presence of mind to suggest the postponement of further inquiry until the suspicious looking instruments could be examined with the advantage of broad day light; and, affecting a tone of severity, he orders these and all other articles belonging to the astronomers to be placed under seal. Delambre immediately addressed a letter to the President of the National Assembly, entreating some specific measure for the protection of himself and his associates. This was done without delay, so that he was able to emerge, after the lapse of three days, from a place of concealment where he had been obliged to remain since the adventures which had threatened to so abruptly terminate his scientific career.

and in great danger,

which they escape.

In 1793 fresh political dificulties arise;

For some time after these events, natural obstacles alone opposed themselves to the progress of the geodesical operations. During the spring of 1793 fresh difficulties arose, from the necessity of constantly procuring new passports, and of exhibiting them almost unceasingly at the demand of every local authority. About this period also, the triangulation having been pushed to the northern extremity of the arc, the observers found themselves close to the scene of war, but by changing a few intended stations, they were able to avoid the awkwardness of carrying on their scientific labours in the presence of two hostile armies. The work had now advanced to the south of Paris; and as the triangulation approached the Loire, it was found essential to construct, on the hill of Chattillon, between Pithiviers and Orleans, a signal of considerable dimensions. As this structure was to serve as a kind of geodesical observatory, it had to be so made as to present not only a wide surface to the autumnal and wintry gales that now began to rage, but also a very conspicuous appearance among surrounding objects. The erection thus became a fruitful source of the most absurd rumours, and had to support, along with the fury of the elements, the equally blind attacks of many a village orator.

and the scientific operations are suspended,

Hitherto the obstacles encountered by the little band of scientific observers had been generally such as would naturally arise at any period, and in any country, from the combined influence of popular ignorance with the excitement consequent on a disturbed state of society. But at Chattillon, they became acquainted with a fact which, for a time, put an end to their labours. The Academy of Sciences had been abolished six months previously; but the Commission for Weights and Measures was retained by a special decree. The party now in power was favourable to the metrical system, but had little sympathy with the fundamental operations required for its establishment. A provisional standard of length, deduced from former measurements, was apparently deemed good enough for definite adoption. The commissioners of the metrical system received hints that it would be desirable to rapidly terminate their labours, and that some of them would very soon be dispensed from further occupation. Not long afterwards Delambre received an official communication, enclosing a decree which is here given *verbatim.*

Du troisième jour de Nivose, l'an deuxiéme de la Republique Française, une et indivisible.

by a decree of the Committee of Public Safety.

Le Comité de Salut Public, considérant combien il importe à l'amelioration de l'esprit public que ceux qui sont chargés du gouvernement ne délèguent de fonction ni ne donnent de mission qu' à des hommes dignes de confiance par leur vertus républicaines et leur haine pour les rois; après s' en être concerté avec

les membres du Comité d' Instruction Publique, occupés specialement de l' opération des poids et mesures, arrête que Borda, Lavoisier, Laplace, Coulomb, Brisson, et Delambre, cesseront, à compter de ce jour, d' être membres de la Commission des Poids et Mesures, et remettront de suite, avec inventaire, aux membres restans, les instruments, calculs, notes, mémoires, et généralement tout ce qui est entre leur mains de relatif a l' operation de mesures. Arrête, en outre, que les membres restans a la Commission des Poids et Mesures, feront connaitre au plutôt au Comité de Salut Public quels sont les hommes dont elle a une besoin indispensable pour la continuation de ses travaux, et qu' elle fera part en même temps de ses vues sur les moyens de donner le plutôt possible l' usage des nouvelles mesures a tous les citoyens en profitant de l' impulsion revolutionnaire.

Le ministre de l' intérieur tiendra la main à l' exécution du présent arrêté.

Political furor adverse to science.

To this document were signed the names of Barère, Robespierre, Billaud-Varrene, Couthon, Collot d' Herbois: thus giving to the decree the character of the strongest testimonial in favour of those against whom it was directed.

Delambre himself seems to have thought that the first part of this decree contained only an empty pretext, and that no one would be so absurd as to suppose that he should quit his signals and instruments in order to display in the clubs his republican sentiments and hatred of kings. Political furor is, however, a strong incentive to absurdities as well as to deeds of oppression; and its hostility to science, whenever the latter cannot be degraded into its service, is sometimes manifested in other countries besides France, and by men claiming for themselves much more coolness, moderation, and wisdom, than the terrorists of the Revolution. The discussion carried on in England about the commencement of the American war as to the comparative merits of lightning conductors terminating in round knobs or in points, deserves on this account a prominent place in the history of science. Notwithstanding, as most readers will anticipate, the almost unanimous opinion of British savans in favour of pointed conductors, the contrary views were countenanced in the highest quarters of the state, because it would be unseemly to adopt the invention of a rebel like Franklin. It is said that the resignation of Sir John Pringle, as President of the Royal Society, at this period, arose from his disinclination to imitate the courtiers of Canute, by asserting the supremacy of the royal prerogative over the laws of the creation. Political or personal prejudices, however, do not preclude the possibility that the Committee of Public Safety, careless of the scientific character of the operations then in progress, sincerely desired that they should be hastened to an end, so as to take advantage of the impelling force of the Revolution in propagating the new system of weights and measures, of which they were to form the foundation. If so, this hope was apparently groundless; for it was not until long afterwards, and in times of unusual tranquillity, that the decimal weights and measures commenced definitively to supersede their antiquated predecessors.

Recommencement of operations in 1794.

The suspension of the geodesical operations did not continue much beyond the period at which the power of those who commanded that suspension had passed away with themselves; and in the spring of 1794 arrangements were made for resuming the work nearly on the same footing as before. In the meantime, Mechain had not only to contend with physical obstacles among the Pyrenees, but also with difficulties arising from the war which had broken out with Spain. The signals marking his stations were frequently destroyed, the instruments and even the observers were sometimes imperilled by the fury of those ascending and descending gusts of wind which are so prevalent among the deep gorges of the mountains. The dangers arising from parties of guerillas were fortunately much diminished by the liberality of the Spanish authorities, who, for a considerable time, invariably granted the utmost freedom of action to the French astronomers. At length, it appeared to the general stationed on the frontier, that the information acquired by Mechain and his companions respecting the country traversed during the operations might prove prejudicial to the interests of Spain, and accordingly the astronomer was ordered not to quit the country.

Embarrassments still encountered

In the autumn of 1794, Delambre recommenced his labours in the neighbourhood of the Loire, but his progress was very slow, from the necessity of defraying all expenses with the now greatly depreciated assignats. After an absence of several months from this quarter, in order to execute the tedious and difficult operation of determining with precision the latitude of Dunkirk, he proceeded with the work to the south of Bourges, among the central districts of France. Some trouble, and much delay, arose in this part of the country, owing to the manner in which church steeples, that would have afforded excellent signals, had been stunted of their proportions by revolutionary fanaticism. One representative of the people had boasted, in a letter to the National Assembly, that he had levelled those steeples which so proudly reared themselves above the humble dwellings of the "*sans cullottes*". Delambre witnessed everywhere that the humble "*sans cullottes*" regretted very much the loss of their steeples; and, on one occasion, having had to supply a church spire, which his triangulations rendered indispensable, its subsequent removal was prevented by the determined opposition of the entire parish. At another station, having covered with white canvas, to render distinct, one side of a pyramid of planks which occupied the place of a levelled church spire, an alarm arose among the people at the sight of a colour in their eyes so significant of counter-revolution; but a complete remedy was soon provided, by attaching to one side of the white canvas a strip of red cloth, and to the other side a strip of blue. This signal was always respected, while another, only a few leagues to the south, was in constant danger. The very day on which it was erected, a violent storm visited the neighbourhood, and the mountain torrents swept an immense volume of earth and gravel into the streets of the adjacent town, where apprehensions were at the same time entertained for the safety of a bridge across the river Dordogne. The signal was blamed for these disasters, and it had also to bear the imputation of causing the heavy rains which for two months suspended agricultural labours among the mountains. Several attempts were made to cause its removal; but, fortunately, its position was almost inaccessible. All the triangulation of the south having been finished, nothing remained but the measurement of the two bases at Melun and Perpignan. These measurements were terminated without any difficulty, except such as are natural in labours requiring so many precautions, and in which the physical observer is compelled to employ every resource that science can bring to his aid.

about geodesical signals.

Commissioners assemble to arrange

Invitations had been long since issued by the French government to neutral and allied countries, in which they were requested to send deputies to Paris, who should assist, along with the commissioners of the Academy of Sciences, in the final settlement of a metrical system adapted to the usage of all nations. Such deputies had been accordingly despatched from the Netherlands, Denmark, Spain, Switzerland, and several states of Italy. The entire body of French and foreign commissioners having assembled about the beginning of the year 1798, divided itself into sub-committees; one, for examining the astronomical and geodesical results of the operations whose history has been partly related; one, for determining the relation of the standard so deduced to previously existing standards; and another for fixing the unit of weight.

the metrical system, and to discuss the results of the measurements.

The labours of the first committee resulted in pointing out some hitherto unknown deviations of the Earth's figure and structure from the more symmetrical conditions which it had been previously supposed to possess. The concordance between the numerical results, as well as the skill and experience of the observers, would not allow the commissioners to attribute these anomalies to errors of observation. The dimensions of the Earth finally deduced, differed but slightly from those already assigned by earlier measurements.

These show certain irregularities in the Earth's figure.

As the length of the arc of meridian was necessarily estimated in terms of the platinum rods employed in the measurement of the bases, the relations of these rods to existing standards would determine the length of the metrical standard in terms of the ancient system of measures. This comparison was made, as usual in all similar cases, by the aid of an apparatus furnished with sliding microscopes and thermometers, so that the most minute differences between the metallic bars submitted to examination could be readily detected. The comparison in the present case amounted rather to a verification of the rods employed in measuring the bases of triangulation, for these rods had been themselves constructed after the toise or fathom called the toise of Peru, which was deposited with the French Academy. From these different processes it appeared that the ten-millionth part of an arc extending from the pole to the equator was 443.3255 lines of the old measure, and a bar of this length was according adopted as the METRE. When the measured arc was afterwards prolonged to Formentera, this value was altered by less than than its sixty-thousandth part. The length afterwards definitively adopted is 443.296 lines; so that the metre is equivalent to a little more than thirty-nine and one-third English inches. The standards

Determination of standards of length and capacity.

of surface and capacity, as may be readily conceived, were deduced from multiples or submultiples of the linear standard. Thus a square ten metres long was designated as the standard of surface for land measure; in other words, the value of this unit is one hundred square metres. The standard of capacity for liquids was determined by finding a cylindrical volume equal to a cube whose edges are formed by tenths of the linear standard. This is the *litre*, a measure somewhat smaller in capacity than one of our imperial quarts.

Selection of a standard of weight.

In order to determine a unit of weight in harmony with the rest of the metrical system, obvious considerations present themselves in guiding the choice of a philosophical inquirer. The weight of any substance depends on its density as well as on its bulk. Density is a property of matter which is known to vary not only among different substances, but also even in the same substance when under different conditions. It became, therefore, desirable to choose a body over whose conditions the utmost control could be exercised, and which could also be easily obtained at all times and in every part of the world. Water possessing the required properties, it was selected as the substance adapted to furnish the best unit of weight. Equal volumes of distilled water, at the same temperature and under ordinary atmospherical conditions, are known to have equal weights all over the world. Like all other bodies, water is susceptible of changes of volume by changes of temperature. It expands when heated beyond its ordinary temperature in our climate; and every person who has experienced a warm bath is aware that the water must be agitated in order to perfectly mingle the warmer liquid, which tends to float, in virtue of its comparative lightness, above the colder and heavier fluid that rests at the bottom. When water cools to a sensible degree below the ordinary temperature, it becomes at first heavier, but after losing a certain amount of heat, it again expands and becomes light, so that, when frozen, the solidified water floats above the liquid mass of which it had formed a part. It thus happens that water has a *maximum* of density; that is, at a certain temperature, a given volume is heavier than an equal volume at any higher or lower temperature. Provided that the water is in a state of purity, this *maximum* is invariable. The weight of a litre of distilled water at its *maximum* density was accordingly adopted as the standard of weight, and called a kilogramme. The preparation of a corresponding mass of metal to be kept for reference, was executed under the superintendence of a skilful physicist, Lefèvre-Gineau, with every precaution required in an operation of such extreme delicacy. This unit of weight had subsequently to be compared with existing units, when it was found to be equivalent to 18827.15 French grains, or a little more than two English pounds avoirdupois.

Nomenclature of the French metrical system,

The units of length, capacity, and weight having been determined, multiples and subdivisions according to the decimal scale were easily framed, and a special nomenclature was devised for the entire system thus invented. This nomenclature had been proposed in different forms, sometimes consisting merely of the names of former measures with a new signification—sometimes with such names slightly modified; that which was at last definitively adopted has no connection with the nomenclature of the older weights and measures. It has nothing French about its character, more than any other group of scientific terms derived from Greek and Latin roots. The words *μέτρον* (measure), *λίτρα* (measure for liquids), and *γράμμα* (small weight), form the foundation of the metrical nomenclature. A thousand times the weight called a gramme, being the most convenient for the unit of weight, was necessarily called a chilogramme, or kilogramme, K being used as the representative of χ for the sake of euphony. The multiples of the units are designated by Greek prefixes, thus: "decametre", for a measure ten metres in length, "hectometre", for one equivalent to one hundred metres. The subdivisions are denoted by Latin prefixes: thus, "decimetre" means a measure equal in length to the tenth part of a metre; while a "millimetre" is the thousandth part of a metre. It is unnecessary to name the rest, and a slight acquaintance with the system shows that most of its terms are nearly superfluous; for the decimal metrical system possesses the great practical advantage of not requiring any technical terms beyond those attached to its units. Thus, instead of writing two hectometres, we might write 200 metres; instead of half a centilitre, $\frac{1}{200}$litre. This course appears to be the most easily intelligible; and as weights and measures are intended for the use of the great mass of mankind, their terminology should be as free as possible from any appearance of learned formality. Had the new system of weights and measures been intended exclusively for France, it an obstacle to its reception.

may perhaps have been prudent to have adopted a nomenclature wholly derived from the vernacular tongue. In the course of a tedious struggle against the active force of prejudices and the formidable inertia of mental indolence, the new metrical system could not have have had any more serious obstacle to its reception among the rural population of France, than its Greco-Latin nomenclature. If that system should be extended to other countries besides those in which it has been already adopted, the terms denoting the units should at most be introduced at first into their languages, the multiples and fractions being expressed by the aid of numbers. Such names are not solely for the purposes of science, where the learner who has any pretensions to acquire knowledge must be prepared to understand compact, though to him strange, terms derived from Greek or Latin roots, which could not be abandoned for corresponding vernacular expressions without the use of a cumbrous and inexact phraseology. A man who never heard of the names of Pericles, Themistocles, or Epaminondas, would scarcely demand their provisional abandonment in a popular exposition of Grecian history, for such names as Smith, Brown, and Thomson, which, although not the most suitable designations of the personages to whom they would be applied, would have the advantage of being more familiar to his ear; and yet the same person would complain of scientific terms, even when fully explained, for no other reason than their unfamiliarity. Absurd as are the objections to scientific language on the part of persons professing to be learners, those useful members of society who are engaged in the active business of life, and who have no pretensions to scientific or literary acquirements, cannot be so fairly expected to quickly master a strange nomenclature applied to some of the objects that constantly occupy their attention and minister to their daily wants.

Gradual progress made by the metrical system.

In connection with the formation of a decimal system of weights and measures in France, the coinage was naturally arranged according to a corresponding system. This soon became much better known and more universally employed than the new system of weights and measures. The use of the old weights and measures, slightly modified, had even to be sanctioned by successive governments, until July, 1837, when a law was passed enforcing, from the beginning of 1840, the exclusive usage of the improved system, as determined by the commission of

1798. Its merits are now practically appreciated not only in France, but in every state of Europe and America, where it has been introduced. A few countries, without adopting the French system, have long since employed some system of decimal coinage or measures. Thus in the United States of America a decimal system of coins coëxists with weights and measures similar to those of Britain.

International Association for uniformity in coins, weights, and measures.

The feeling which has been long growing in favour of a decimal system in England, and which parliamentary inquiries from time to time so clearly reveal, has very recently received a considerable accession of strength. The industrial exhibition of 1855, held in Paris, having attracted to that capital an unusual concourse of the thoughtful as well as practical minds of every nation, meetings were held for the discussion of suitable projects for inducing all civilized powers to unite in adopting a system of weights, measures, and coins, adapted to the requirements of all mankind. An international association, centred in Paris, with branches in the principal states of Europe and America, was accordingly organized under the presidency of Baron Rothschild. This body has already effected considerable progress in the objects for which it was established; and, chiefly through the exertions of Mr. James Yates, of London, the English branch has succeeded in exciting a feeling throughout these countries which promises to give the consideration of a new system of weights, measures, and coins, a far wider basis than it had previously possessed.

Reasons for believing that such a system will be universally adopted.

The advantages to the entire human race which a universal metrical and monetary system would confer, are now very generally admitted; but doubts are entertained as to the practicability of so great an achievement. Such doubts arise partly from the known obstacles presented by the habits and mental indolence of the majority of society; but similar improvements have triumphed in every country over the same difficulties, and in some nations a uniform decimal monetary and metrical system has already gained possession of the shop, the counting-house, and the market. A system established in conformity with mental habits that belong to all mankind, which takes its standard of length from the dimensions of the planet of which they are common inhabitants, and its standard of weight from that liquid which is at once the most useful to man and the most universally diffused, cannot assuredly be accused of exhibiting any peculiarities merely local, or any traces of being subservient to the advancement of the views of a political party. That all these qualities are possessed by the French metrical system, no person can doubt, who examines the history of its origin, and meditates over its philosophical character. Objections, in some measure well founded, have been raised by a few eminent scientific men in England against the adoption of standards found in nature. The length of the seconds' pendulum and the dimensions of the Earth, are the only two invariable quantities which appear to be within our reach; but their determinations do not give strictly the same results in every country. The Earth's figure is not perfectly regular, nor is its structure homogeneous. The meridians in different countries, although curves very similar, are not precisely alike; and the lengths corresponding to the same celestial arc, will differ from one meridian to another. If lines traced on the true surface of the Earth, over hill and valley, were those estimated, the discrepancies would probably be still greater; but those which are measured, although independent of small local irregularities, are affected by the greater deviations of the Earth's figure from an ellipsoid of revolution. The length of an invariable pendulum depends on the intensity of gravity at the place where it is set in vibration. This intensity, as might be expected *a priori*, varies not only in going from the equator to the pole, but also sometimes, though in a less degree and with less regularity, in the direction of the parallels. The differences between the results of dimensions of the Earth, obtained from distant geodesical operations, and of the lengths of the second's pendulum, as determined by different observers at different stations, although far below what are required to be considered in the formation of a standard of length for ordinary operations, yet may become important in connection with scientific determinations where a higher degree of precision is desirable. On this account it has even been proposed to abandon natural standards altogether, and to merely adopt the old system with additional precautions of inclosing the standards in a place of safety, whence they could be obtained for rarely occurring and important national objects, only with great trouble and with the sanction of the highest legislative authority. The establishment of a natural standard does not, however, preclude the fulfilment of such an arrangement—the preserved stan-

Objections to standards found in nature,

shown to be invalid.

dard would always necessarily retain the higher authority; but this should not prevent the existence of some provision against its injury or loss. Even were these contingencies completely obviated, it would manifestly contribute to the cosmopolitan character of a universal standard, if it were either the length of the second pendulum at the equator, or a fraction of the Earth's dimensions, approaching to the truth far more closely than the ordinary purposes of society would ever be likely to require.

Suggestion of a new standard if another should be desirable.

A standard based on no philosophical idea whatever, could only be proposed for the exclusive use of a single nation, and is certainly far from being inappropriate wherever the entire system of division of weights and measures has no pretension to be in harmony with the numerical scale which forms the basis of all computation. The slight deviations of the Earth's figure from that of an ellipsoid of revolution, rendering its meridians dissimilar, might suggest the adoption of another ideal standard, if the subject is really worthy of serious reconsideration. The axis of rotation of the Earth is common to every meridian, and its most correct value is obtained by a comparison of the measurements of several different arcs belonging to different meridians. An easily remembered fraction of this axis might form a standard of length, which would be less liable to vary in its estimated value than a fraction derived directly from an arc of a meridian, the influence of the physical peculiarities of the countries through which the measured arcs happen to pass would be nearly eliminated, and the final result would be of a kind to which every country would have the same relation. I am, however, far from proposing the adoption of a new standard, and I make this suggestion only as a mode for overcoming any difficulties that may impede the reception of the metrical system among those great nations into whose shops and markets it has not as yet found its way.

General use of the decimal system for the purpose of science.

It is natural to suppose that the philosophical excellence and practical advantages of the new metrical system would be most readily acknowledged among scientific circles. It has been accordingly for many years introduced into scientific cabinets and laboratories over the greater part of Europe, and with or without the coöperation of governments, has made itself familiar to a large number of the better educated classes of every country.

Besides the estimation of length, surface, volume, and weight, in science and the useful arts, it is often necessary

Estimation of heat according to a decimal system.

to estimate relative quantities of heat. For this purpose, a universal standard presents itself, in the property by which water under the same pressure boils and freezes at fixed temperatures. The interval between these temperatures has accordingly been adopted as the standard for measuring heat. Its division into 100 degrees, long since proposed by the Swedish philosopher Celsius, has gradually superseded the division into eighty degrees introduced by Reaumur in France. The centigrade or hundred-degree thermometer is completely in harmony with the decimal metrical system, and the one is likely to be fairly appreciated wherever the advantages of the other have been felt. Although the somewhat arbitrary thermometrical scale introduced by Fahrenheit has held its ground up to the present time in Great Britain, the inferiority of that scale to its more philosophical competitor is now beginning to be felt, and the latter has been recently adopted by eminent English physicists in an extensive series of researches on the mechanical and molecular conditions of heat. The increasing attention which the climate of the globe is constantly receiving, and the vast number of observations which are now made, both on land and sea, render it extremely desirable that a uniform system should be pursued in estimating the most important of all climatological elements. On this account alone, if a universal system of weights and measures should be established, the thermometrical scale must claim a share in the improvement—a change which will fortunately be of the simplest nature, as it will only require that a selection be made of one scale out of the three that have been generally received among civilized nations.

Present arrangement of the French coinage.

The arrangement of coins according to a decimal scale is easily understood. Thus, the franc being the basis of the French coinage, its multiples are—in gold, the pieces of 100fr., 50fr., 20fr., and 10fr.; in silver, those of 5fr. and 2fr. Its hundredth part is called the centime; and the multiples of that in silver are, 50c. and 20c.; in copper or bronze, 10c., 5c., and 2c. These are numbers belonging to the decimal scale, because those less than ten evenly divide it, and those less than one hundred are also even divisors of that number. The introduction of such a system into accounts immediately removes a mass of superfluous figures. In cases where per-centages of sums of money are estimated, no calculation whatever is necessary; all that is required is done by changing the place of a decimal point. The obvious advantages of decimal coinage and accounts have lately forced themselves on the attention of our legislature. All the evidence collected by a Committee of the House of Commons, in their comparatively recent inquiries, points in one direction, namely, that of proving the superiority of a decimal system of coinage and accounts over every other. In order to realize this preference of a decimal coinage, it is proposed to make a few alterations in the present coinage, by which the whole would become decimalized. Calling the thousandth part of a sovereign a mil, the proposed scale would stand thus:

Decimal coinage of Great Britain recommended by a Committee of the House of Commons.

1,000 mils=1 sovereign.
500 mils=½ sovereign.
250 mils=1 crown.
100 mils=1 florin.
50 mils=1 shilling.
25 mils=6 pence.
20 mils=2 cents.
10 mils=1 cent.
5 mils=½ cent.
2 mils, and
1 mil.

The cent and mil would thus be entirely new coins, the value of the former being nearly 2½ pence, and that of the latter less than a farthing by only its $\frac{1}{24}$th part. It is proposed to make the cent a silver coin, while the three inferior coins are to be copper.

If this improvement should be effected in the manner proposed, it will probably soon lead to a similar reform in weights and measures. It is said that the people would soon be demanding a decimal metrical system in everything; but why wait in a question of this nature for demands from the people? The reform is not of a nature calculated to make a stirring party cry, or to excite the political feelings of the multitude. After Lord Chesterfield had prevailed upon the legislature to pass his bill for the establishment of the Gregorian Calendar in England, and when he heard from the crowds surrounding his carriage, cries of "give us back our three months", he would assuredly smile at the simplicity of any one who would say that we should make no improvement in our mode of counting time or space, except as a result of popular expressions in its favour. If, therefore, the indisputable merits of a decimalized system of weights and measures, as well as of coins, should render its establish-

Similar steps for weights and measures

should not be delayed.

ment desirable, why should not some attempt be made to mould it in harmony with the systems of other nations? The evils resulting from the existing diversity of weights and measures among provincial districts of Great Britain and Ireland, are now seen and felt more than ever, because mutual intercourse has increased. Great nations are the world's provinces, and among them also intercourse is rapidly extending. Each people has peculiarities; some of which, were it even possible, it would perhaps not be desirable to change; but there are certain traits of mental as well as of physical character which are common to all alike. The idea of establishing a universal system of coins, weights, and measures is suggested by the notions of the fundamental nature of numbers and quantity possessed in common by all mankind. If several nations separately find themselves induced to adopt metrical systems identical in numerical arrangements, why not make them identical in all respects? That metrical system, whose origin and history has been briefly sketched in the foregoing pages, appears to present all the characters of universality that would adapt it for general use among mankind.

It seems impossible to conceive any mode in which the French metrical system could be improved, except perhaps by some modification of the standards on which it is based. Should this appear desirable in other countries, where the tendency towards its adoption is growing, why not propose some readjustment of the question of standards?

The adoption of the French system might be settled by plenipotentiaries.

The plenipotentiaries of the great powers of Europe have often met to debate over the settlement of a frontier, which would determine the temporary disposal of a few square leagues of territory: would it less become an assembly of the representatives of nations to finally concur in an arrangement that would give equal advantages to all, and by which misunderstandings between countries as well as between individuals would be rendered probably less frequent, and certainly less complicated?

JOHN F. FOWLER, Printer, 3 Crow Street, Dame Street, Dublin.

A FINE IS INCURRED IF THIS BOOK IS NOT RETURNED TO THE LIBRARY ON OR BEFORE THE LAST DATE STAMPED BELOW.

3 8 2 92

MAR 2 6 1973
CANCELLED
FEB 27 1992 H

Phys 428.58.5
On a uniform system of weights, mea
Cabot Science 003435179

3 2044 091 954 289